UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
PESTICIDES AND TOXIC SUBSTANCES

MEMORANDUM

SUBJECT: Bifenthrin Exposure Assessment

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EAB has completed an assessment of worker exposure to bifenthrin. Exposure estimates have been provided for pilots, flaggers, applicators and mixer/loaders and include ground boom, airblast, hand spray and aerial application techniques. A copy of the assessment is attached.

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1.0 INTRODUCTION

EAB has been requested to provide worker exposure estimates for bifenthrin so that the Toxicology Branch can complete a risk assessment for this chemical. Due to time constraints, and because EAB has no data measuring exposure to bifenthrin, this exposure assessment was conducted using surrogate studies from EAB's data base, and usage parameters provided by the Benefits and Use Division (BUD) for other chemicals.

Bifenthrin is a synthetic pyrethroid insecticide/miticide, currently registered for use on ornamentals, trees and shrubs. Proposed use sites include walnuts, pecans, peaches, pears, strawberries, and cotton. Bifenthrin is available as a 10% wettable powder and as a 2 lb/gal emulsifiable concentrate. The wettable powder formulation is available in water soluble bags. Since EAB has no data demonstrating the effect of using water soluble bags on mixer/loader exposure, exposure estimates for the wettable powder formulation of bifenthrin will be based on conventional mixing/loading operations.

Bifenthrin may be applied using ground, airblast, hand spray equipment or aerially. Application rates range from 0.01 to 0.2 lb a.i./A. For this exposure assessment, data from surrogate studies were adjusted to the maximum label rate for each use site. Since the studies used to create EAB's generic database were conducted using higher application rates than those proposed for this product, extrapolation to the lower application rates may be less precise. Label instructions require the use of a face mask or respirator when handling bifenthrin.

The following assumptions were required in this assessment:

1. An average worker weighs 70 kg.

2. Exposures are not adjusted for dermal absorption.

3. Fifty percent of the bifenthrin that reaches worker clothing penetrates the clothing.

4. Standard work clothing includes long-sleeved shirts and long pants.

5. Respiratory exposure is negligible compared to dermal exposure.

2.0 MIXER/LOADER EXPOSURE

A search of the published literature produced four articles containing useful information for mixer/loaders in agricultural scenarios in which exposure could be expressed in mg/lb a.i. handled. Exposure estimates were calculated for a mixer/loader

wearing long sleeved shirts and long pants, but no protective gloves. Annual exposure estimates for mixer/loaders have been calculated using the maximum label rate for each use site.

2.1 Liquid Formulations

The Abbott (1), Lavy (2), and Dubelman (3) studies provided 25 replicates in which mixer/loader exposure could be expressed in mg/lb a.i. handled. An open loading system was used in these studies. The mean exposure for the 18 Abbott replicates was 5.4 mg/lb a.i., for one Lavy replicate it was 0.15 mg/lb a.i., and for six Dubleman replicates it was 2.7 mg/lb a.i. Based on a weighted average, the dermal exposure to mixer/loaders not wearing gloves and using an open loading system was 4.5 mg/lb a.i.

Annual exposure estimates for workers using open loading systems, adjusted for 70 kg workers and for maximum label rates for bifenthrin are:

Peaches and cotton

$$\frac{4.5 \text{ mg}}{1 \text{ lb a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.0 \text{ lb a.i.}}{\text{year}} = 6.4 \times 10^{-2} \text{ mg/kg/year}$$

Pecans

$$\frac{4.5 \text{ mg}}{1 \text{ lb a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.6 \text{ lb a.i.}}{\text{year}} = 0.10 \text{ mg/kg/year}$$

Pears

$$\frac{4.5 \text{ mg}}{1 \text{ lb a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.75 \text{ lb a.i.}}{\text{year}} = 4.8 \times 10^{-2} \text{ mg/kg/year}$$

Walnuts and strawberries

$$\frac{4.5 \text{ mg}}{1 \text{ lb a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.8 \text{ lb a.i.}}{\text{year}} = 5.1 \times 10^{-2} \text{ mg/kg/year}$$

Only one study containing two replicates was evaluated in which the mixer/loader did not wear gloves while using a closed system (2). A deficiency in this surrogate study was the failure to measure hand exposure. Hand exposure had to be estimated from forearm exposure. In light of the absence of other studies, this exposure estimate should be used cautiously. Based on only two replicates, the exposure to mixer/loaders not wearing gloves and using a closed loading system was 0.013 mg/lb a.i. Annual exposure estimates for closed loading systems, adjusted for 70 kg workers and for maximum label rates for bifenthrin are:

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Peaches and cotton

$$\frac{0.013 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.0 \text{ 1b a.i.}}{\text{year}} = 1.9 \times 10^{-4} \text{ mg/kg/year}$$

Pecans

$$\frac{0.013 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.6 \text{ 1b a.i.}}{\text{year}} = 3.0 \times 10^{-4} \text{ mg/kg/year}$$

Pears

$$\frac{0.013 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.75 \text{ 1b a.i.}}{\text{year}} = 1.4 \times 10^{-4} \text{ mg/kg/year}$$

Walnuts and strawberries

$$\frac{0.013 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.8 \text{ 1b a.i.}}{\text{year}} = 1.5 \times 10^{-4} \text{ mg/kg/year}$$

2.2 Wettable Powder Formulations

Only one study was available in which mixer/loader exposure to wettable powder formulations could be expressed in mg/lb a.i. (4). In this study, eight mixer/loaders not wearing gloves and pouring the concentrate were exposed to 1.1 mg/lb a.i. Annual exposure estimates, adjusted for 70 kg workers and for maximum label rates for bifenthrin are:

Peaches and cotton

$$\frac{1.1 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.0 \text{ 1b a.i.}}{\text{year}} = 1.6 \times 10^{-2} \text{ mg/kg/year}$$

Pecans

$$\frac{1.1 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{1.6 \text{ 1b a.i.}}{\text{year}} = 2.5 \times 10^{-2} \text{ mg/kg/year}$$

Pears

$$\frac{1.1 \text{ mg}}{1\text{b a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.75 \text{ 1b a.i.}}{\text{year}} = 1.2 \times 10^{-2} \text{ mg/kg/year}$$

Walnuts and strawberries

$$\frac{1.1 \text{ mg}}{\text{lb a.i.}} \times \frac{1}{70 \text{ kg}} \times \frac{0.8 \text{ lb a.i.}}{\text{year}} = 1.3 \times 10^{-2} \text{ mg/kg/year}$$

3.0 PILOT EXPOSURE

A total of 29 replicates from six studies were evaluated to estimate dermal exposure to pilots. Dermal exposure was calculated assuming the pilots wore long pants and long-sleeved shirts which reduced exposure to the covered areas by 50%. The mean dermal exposure to pilots from the six studies were as follows:

Lavy (2)	0.064 mg/hr	3 replicates
Lavy (5)	0.082 mg/hr	1 replicate
Maddy (6)	0.006 mg/hr	4 replicates
Peoples (7)	0.188 mg/hr	11 replicates
Mumma (8)	0.20 mg/hr	6 replicates
Atallah (9)	0.076 mg/hr	4 replicates

The exposure estimates presented above were adjusted to an application rate of 0.2 lb a.i./A, which represents the maximum label rate for peaches, pecans, and strawberries. The weighted average for this application rate for dermal exposure to pilots is 0.13 mg/hr. For cotton (maximum rate of 0.1 lb a.i./A), the weighted average is 0.065 mg/hr. Based on usage information from the Benefits and Use Division for other insecticides, aerial applicators may treat 400 acres in a day and require 5 hours of actual spray time. Aerial applications are made ten times per year for cotton and five times per year for other use sites.

Peaches, pecans and strawberries

$$\frac{0.13 \text{ mg}}{\text{hr}} \times \frac{1}{70\text{kg}} \times \frac{5 \text{ hr}}{\text{day}} \times \frac{5 \text{ days}}{\text{year}} = 4.6 \times 10^{-2} \text{ mg/kg/year}$$

Cotton

$$\frac{0.065 \text{ mg}}{\text{hr}} \times \frac{1}{70\text{kg}} \times \frac{5 \text{ hr}}{\text{day}} \times \frac{10 \text{ days}}{\text{year}} = 4.6 \times 10^{-2} \text{ mg/kg/year}$$

4.0 FLAGGER EXPOSURE

Lavy (5), Maddy (6), Peoples (7), and Atallah (9) were evaluated to estimate flagger exposure. The four studies measured

dermal exposure to 24 flagger replicates. It should be noted that flagger exposure was extremely variable, with wind shifts producing dermal exposures as high as 1,700 mg/hr. A review of the study indicated that some flaggers remained upwind of the spray drift while others got caught by wind shift which exposed them directly to the spray. The estimates were calculated assuming that the flaggers wore long-sleeved shirts and long pants which reduced exposure by 50% to the torso and limbs.

The estimates from the individual studies were adjusted to an application rate of 0.2 lb a.i./A, and are as follows:

Lavy (5)	0.22 mg/hr	2 replicates
Maddy (6)	0.064 mg/hr	8 replicates
Peoples (7)	0.48 mg/hr	11 replicates
Atallah (9)	4 mg/hr	3 replicates

The weighted average for this application rate, representing the maximum label rate for peaches, pecans, and strawberries is 0.76 mg/hr. For cotton (maximum label rate of 0.1 lb a.i./A), the weighted average is 0.38 mg/hr. Annual exposure estimates, based on the usage data supplied for pilots in Section 3.0, and adjusted for 70 kg workers are:

Peaches, pecans and strawberries

$$\frac{0.76\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{5\ \text{days}}{\text{year}} = 0.27\ \text{mg/kg/year}$$

Cotton

$$\frac{0.38\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{10\ \text{days}}{\text{year}} = 0.27\ \text{mg/kg/year}$$

5.0 GROUND BOOM APPLICATION EXPOSURE

A total of six studies containing 92 replicates were evaluated to estimate ground boom applicator dermal exposure. Of the two bifenthrin use sites for which ground equipment is used for application, only cotton will be covered in this assessment. The exposure estimates were calculated assuming the applicators wore long-sleeved shirts and long pants which reduced the exposure by 50% to the covered areas. The estimates from individual studies were adjusted to an application rate of 0.1 lb a.i./A and are as follows:

Staiff (10)	0.04 mg/hr	20 replicates
Abbott (1)	4.4 mg/hr	18 replicates
Wojeck (11)	14.6 mg/hr	23 replicates
Dubelman (3)	0.033 mg/hr	3 replicates
Maitlen (12)	0.07 mg/hr	21 replicates
Wolfe (13)	0.94 mg/hr	7 replicates

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Because the exposure values are skewed over a three orders of magnitude range, ground boom risk estimates should not be based on a weighted arithmetic mean. A weighted geometric mean was calculated because of the distribution of the exposure estimates. Therefore, the lowest exposure of 0.033 mg/hr, the highest exposure of 14.6 mg/hr, and the geometric mean of 0.63 mg/hr were used.

The variation in dermal exposures was not unexpected and results from differences in open versus closed tractor cabs, individual habits, boom placement, weather, and other factors. Based on usage information supplied by the Benefits and Use Division for other chemicals, applicators may treat 241 acres of cotton in 2.5 days, and spend 5 hours per day applying bifenthrin. According to label directions, bifenthrin may be applied to cotton up to 10 times per season. Annual exposure estimates, adjusted for 70 kg workers are:

$$\text{Low exposure} = \frac{0.033\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{2.5\ \text{days}}{\text{appl.}} \times \frac{10\ \text{appl.}}{\text{year}}$$

$$= 5.9 \times 10^{-2}\ \text{mg/kg/year}$$

$$\text{Mean exposure} = \frac{0.63\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{2.5\ \text{days}}{\text{appl.}} \times \frac{10\ \text{appl.}}{\text{year}}$$

$$= 1.1\ \text{mg/kg/year}$$

$$\text{High exposure} = \frac{14.6\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{2.5\ \text{days}}{\text{appl.}} \times \frac{10\ \text{appl.}}{\text{year}}$$

$$= 26\ \text{mg/kg/year}$$

6.0 HANDSPRAY EXPOSURE

A total of four studies were evaluated in which a handheld sprayer was used. Applicator exposure from the four studies was adjusted to a tank concentration of 0.024% a.i. (maximum label rate for ornamentals) and assumed that the applicators wore long-sleeved shirts and long pants which reduced exposure to covered areas by 50%. The 49 replicates had the applicators spraying lawns, shrubs and trees. The direction the spray nozzle is

pointed will affect the overall exposure and distribution of exposure to the body; however, the number of replicates was too small to subdivide by direction of spray. The adjusted dermal applicator exposures from the four studies were as follows:

Abbott (1)	2.3 mg/hr	12 replicates
Copplestone (14)	0.43 mg/hr	8 replicates
Davis (15)	2.6 mg/hr	17 replicates
	2.9 mg/hr	9 replicates
Everhart (4)	0.84 mg/hr	3 replicates

The weighted average for dermal exposure to spray gun applicators using a spray concentration of 0.024% is 2.1 mg/hr. Based on usage information supplied for other chemicals, it is reasonable to assume that commercial applicators would use bifenthrin up to 100 hours per year. Annual exposure for this use is therefore 3 mg/kg/year.

7.0 AIRBLAST EXPOSURE

Exposure of workers using airblast equipment to apply bifenthrin to peaches, pecans, pears and walnuts was based on a regression equation derived from surrogate data (16). The equation for dermal exposure is:

$$\text{Exposure (mg/hr)} = 4.8\ (1\text{b a.i./A}) + 16$$

$$= 4.8\ (0.2\ 1\text{b a.i./A}) + 16$$

$$= 17\ \text{mg/hr}$$

Annual exposure adjusted for 70 kg workers applying bifenthrin 5 times per year at 5 hours per day is:

$$\frac{17\ \text{mg}}{\text{hr}} \times \frac{1}{70\ \text{kg}} \times \frac{5\ \text{hr}}{\text{day}} \times \frac{5\ \text{days}}{\text{year}} = 6.1\ \text{mg/kg/year}$$

8.0 CONCLUSION

Based on data from surrogate studies and on usage parameters provided by BUD for other chemicals, dermal exposure of mixer/loaders handling the emulsifiable concentrate formulation of bifenthrin is estimated to range from 4.8×10^{-2} to 0.10 mg/kg/year and 1.4×10^{-4} to 3.0×10^{-4} mg/kg/year for open and closed loading systems, respectively. Annual exposure to mixer/loaders using the wettable powder formulation of bifenthrin is estimated to range from 1.2×10^{-2} to 2.5×10^{-2} mg/kg/year. Annual exposure to pilots and flaggers is estimated to be 4.6×10^{-2} and 0.27 mg/kg/year, respectively. Applicator exposures are estimated to

be: 1.1 mg/kg/year (mean exposure, ground boom), 3 mg/kg/year (hand spray), and 6.1 mg/kg/year (airblast). A summary of bifenthrin exposures is shown in Table 1.

These estimates assume that workers are wearing long-sleeved shirts and long pants; protective gloves are not worn. Because the use of protective gloves is a common sense safety practice that is known to substantially reduce dermal exposure, EAB recommends that bifenthrin labels be amended to include the wearing of protective gloves. The exposure estimates are not adjusted for dermal absorption.

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Table 1. Summary of Annual Exposures to Bifenthrin.

Use pattern		Exposure (mg/kg/year)
MIXER/LOADER - LIQUID FORMULATION		
Open loading system:	Peaches and cotton	6.4 x 10-2
	Pecans	0.10
	Pears	4.8 x 10-2
	Walnuts and strawberries	5.1 x 10-2
Closed loading system:	Peaches and cotton	1.9 x 10-4
	Pecans	3.0 x 10-4
	Pears	1.4 x 10-4
	Walnuts and strawberries	1.5 x 10-4
MIXER/LOADER - WETTABLE POWDER FORMULATION		
Open loading system:	Peaches and cotton	1.6 x 10-2
	Pecans	2.5 x 10-2
	Pears	1.2 x 10-2
	Walnuts and strawberries	1.3 x 10-2
PILOTS		
Peaches, pecans and strawberries		4.6 x 10-2
Cotton		4.6 x 10-2
FLAGGERS		
Peaches, pecans and strawberries		0.27
Cotton		0.27

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Table 1 cont.

Use pattern	Exposure (mg/kg/year)
GROUND BOOM APPLICATORS	
Low exposure	5.9×10^{-2}
Mean exposure	1.1
High exposure	26
HAND SPRAY APPLICATORS	3
AIRBLAST APPLICATORS	6.1

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